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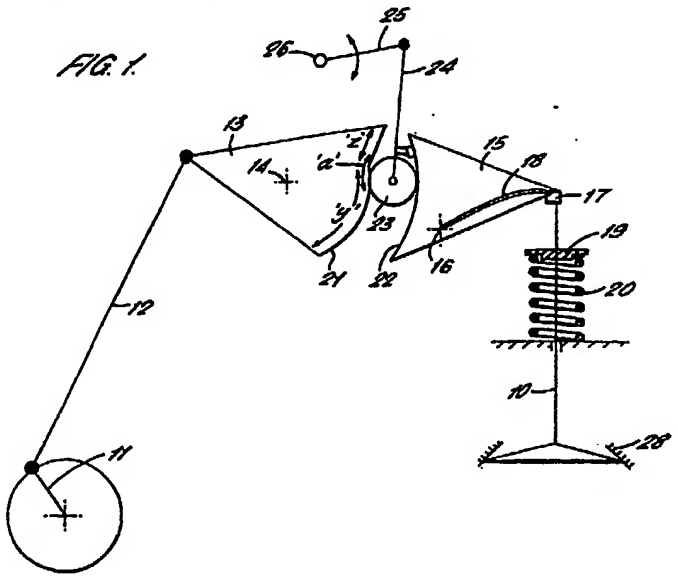
(54) Abstract Title
Valve operating mechanism

(57) With reference to Figure 1, the present invention relates to a valve operating mechanism for operating a poppet valve (10). The mechanism comprises a first rocker (13) which is pivotally mounted on a first rocker shaft (14) and which is driven to pivot in an oscillatory manner. A second rocker (15) which is pivotally mounted on a second rocker shaft (16) spaced apart from the first rocker shaft (14) and engages the poppet valve (10) so that pivoting of the second rocker (15) causes motion of the poppet valve (10). The first rocker has a cam surface (21) and cam follower means (23) engages the cam surface (21) and relays a camming action to the second rocker (15) to cause the second rocker (15) to rotate and thereby impart motion to the poppet valve (10). The first rocker (13) is driven to pivot about the first rocker shaft (14) by a drive mechanism which includes a rotating shaft (11) and a connecting link (12) pivotally attached to the rotating shaft (11) at a point displaced from the axis of the shaft (11). Rotation of the shaft (11) is used to drive the first rocker (13) to pivot about the first rocker shaft (14) both clockwise and anti-clockwise.

FIG. 1.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

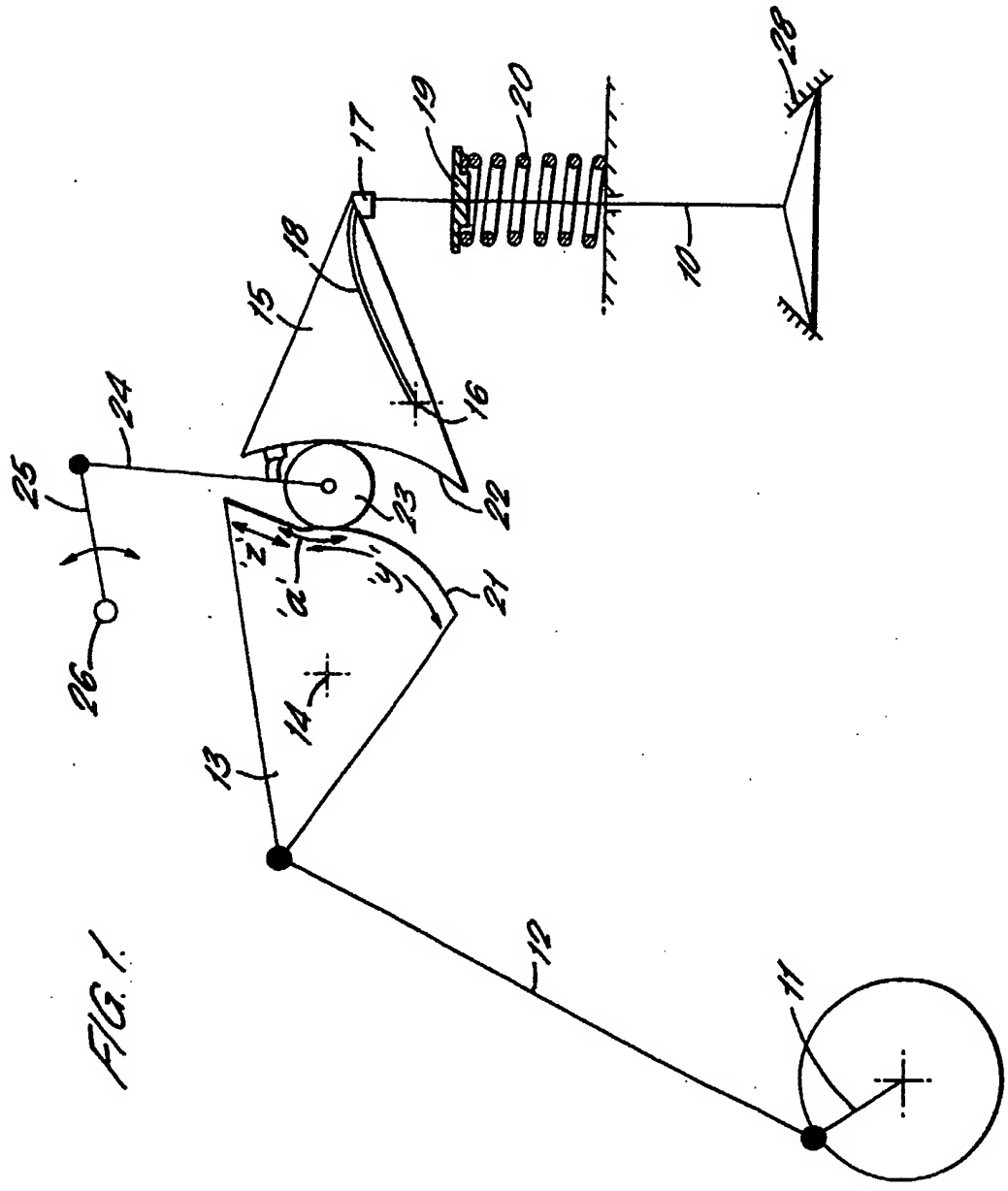
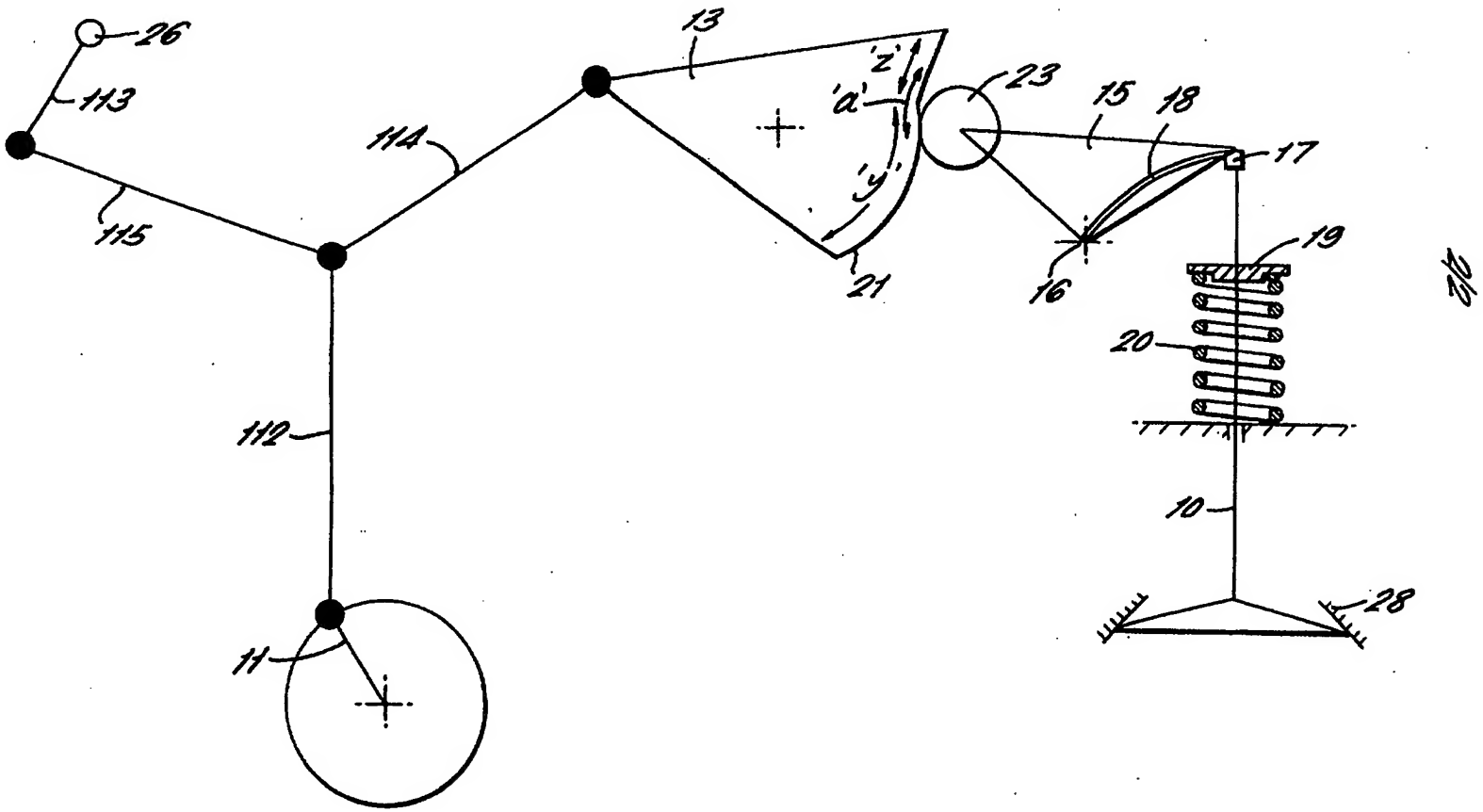


FIG. 1

FIG. 2.



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Valve Operating Mechanisms

The present invention relates to valve operating mechanisms suitable for operating poppet valves of an internal combustion engine.

Poppet valves are typically used as inlet and exhaust valves of an internal combustion engine, controlling gas flow into and out of working cylinders. The poppet valves of an engine are typically driven by cams on one or more camshafts of the engine. Historically the motion of each valve was controlled by the profile of a single cam and remained unchanged with changes in engine speed or load. However, it has been appreciated by many that it is advantageous to vary the opening period of a poppet valve and its lift with changing engine speeds and loads and many mechanisms have been proposed to achieve this.

In WO95/09298 there is shown an embodiment of valve operating mechanism for operating a poppet valve in a push rod internal combustion engine. The mechanism has a cam connected to a crankshaft of the engine to rotate with rotation of the crankshaft. The cam via a push rod drives a first rocker to oscillate about a first rocker shaft. A cam surface of a chosen profile is provided on the rocker. A second rocker on a second rocker shaft engages the poppet valve. A cam follower is mounted on the second rocker and also engages the cam surface on the first rocker. The motion imparted by the cam surface to the cam follower is relayed to the second rocker which oscillates about its pivot shaft and thereby drives the poppet valve to open. A return spring acting on the poppet valve acts

to return the open valve to its seat. The motion of the poppet valve can be varied by selecting which part of the cam surface is engaged by the cam follower in each oscillation of the first rocker. A first part of the cam surface can be designed such that no lift is imparted to the poppet valve as the cam follower follows the cam surface. Another part of the cam surface can be designed to impart a lift to the valve. The cam follower is moved relative to the second rocker in order to effect the selection of an appropriate part of the cam surface.

The mechanism of WO95/09298 has a disadvantage. A spring is required to keep a tappet fixed to the end of the push rod in engagement with the cam on the cam shaft in order to maintain valve train integrity. This has a particularly limiting effect when the poppet valve is closing since the spring force is relied upon not only to keep the follower in engagement with the rotating cam, but also to rotate the first rocker and move other valve train components such as the push rod.

The present invention provides a valve operating mechanism for operating a poppet valve comprising: a first rocker which is pivotally mounted on a first rocker shaft and which is driven to pivot in an oscillatory manner about the first rocker shaft; a second rocker which is pivotally mounted on a second rocker shaft spaced apart from the first rocker shaft and which engages the poppet valve so that pivoting of the second rocker causes motion of the poppet valve; wherein the first rocker has a cam surface; and cam follower means engages the cam surface of the first rocker and relays a camming action of the cam

surface to the second rocker to cause the second rocker to rotate about the second rocker shaft and thereby impart motion to the poppet valve; characterised in that the first rocker is driven to pivot about the first rocker shaft by a drive mechanism which includes a rotating shaft and a connecting link pivotally attached to the rotating shaft at a point displaced from the axis of the shaft whereby the rotation of the shaft is used to drive the first rocker to pivot about the first rocker shaft both clockwise and anti-clockwise.

In the valve operating mechanism of the present invention the first rocker is positively driven in both senses of oscillation and this removes the limitations presented by the need for a return spring mechanism in the prior art. Furthermore the components located at the cylinder head (where space is tight) are reduced in size and number.

Preferred embodiments of valve operating mechanisms according to the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a schematic drawing of a first embodiment of valve operating mechanism according to the present invention; and

Figure 2 is a schematic drawing of a second embodiment of valve operating mechanism according to the present invention.

Turning first to Figure 1 there can be seen a valve operating mechanism for operating a poppet valve

10. The illustrated poppet valve is an inlet valve of an internal combustion engine of an automobile, controlling flow of gases into a working cylinder (not shown).

The valve operating mechanism comprises an eccentric shaft 11 which is directly driven by a crankshaft of the engine (not shown) which is in turn connected directly or indirectly to pistons of the engine reciprocating within its working cylinders so that the motion of the crankshaft 12 is directly linked to the motion of the pistons. The eccentric shaft 11 will rotate at a ratio of 2:1 (two revolutions of the crankshaft to one rotation of the eccentric shaft) when the engine operates on a four stroke OTTO cycle or 1:1 when the engine operates on a two stroke cycle. A connecting rod 12 is pivotally attached at one end to a throw of the crankshaft 11 and at the other end to a rocker 13 pivotally mounted on a rocker shaft 14 and freely rotatable about the rocker shaft 14. The rocker 13 has a cam surface 21 machined thereon.

A second rocker 15 is freely pivotal about a second rocker shaft 16, spaced apart from and parallel to the rocker shaft 14. A hydraulic lash adjuster 17 is located in the rocker 15, supplied by an oil passage 18 leading from the rocker shaft 16. The rocker shaft 16 is hollow and carries an oil supply which is relayed to the oil passage 18 via an aperture in the shaft 16. The lash adjuster 17 abuts the top of a stem of the poppet valve 10. The rocker 15 has a reaction surface 22 machined thereon, the nature and purpose of which will be described later.

A collar 19 is fixed to the top of the stem of the poppet valve 10 and a valve spring 20 acts between a fixed point and the collar 19 in order to bias the poppet valve into engagement with its seat (i.e. into a closed position).

Linking the rocker 13 and the rocker 15 is a roller follower 23. The roller follower 23 simultaneously engages both the cam surface 21 of rocker 13 and also the reaction surface 22 of the rocker 15. The roller follower 23 is rotatably mounted on the end of a control arm 24 which in turn is pivotally connected to an end of a control arm 25 which is mounted on a control shaft 26 to rotate with the control shaft 26. The control shaft 26 is rotated by an electric motor (not shown) under the control of an electronic control system.

The rotating eccentric shaft 11 via the connecting rod 12 drives the rocker 13 to rotate about the rocker shaft 14 in an oscillatory manner. This oscillatory motion can be transmitted via the roller follower 23 to the rocker 15 to cause the rocker 15 to pivot about the rocker shaft 16 in an oscillatory manner. When the rocker 15 rotates clockwise then it drives the poppet valve 10 open (i.e. lifts the poppet valve 10 away form its seat).When the rocker 15 pivots anti-clockwise ,under the influence of the valve spring 20, it allows the valve 10 to close (i.e. to engage its valve seat). The rotation of the rocker 15 is dictated by a camming action of the control surface 21.

The control surface 21 has a constant radius portion 'y' which is of a constant distance from the

rocker shaft 14. When the roller follower 23 moves over the part 'y' of the surface 21 (as the rocker 13 rotates) no rotation is conveyed to the rocker 15 and thus no lift is imparted to the poppet valve 10 by the operating mechanism.

The control surface 21 has a portion 'z' which follows on from the portion 'y' and which increases in distance from the rocker axis 14. When the roller follower 23 engages the portion 'z' of the control surface 21 then a camming action of the control surface causes the roller follower 23 to act on the reaction surface 22 to rotate the rocker 15 clockwise about the shaft 16 and thereby to move the poppet valve 10 away from its valve seat 28.

The roller follower 23 rolls along the cam surface 21 of the rocker 13 as the rocker 13 pivots. The lift imparted to the valve 10 is a controlled by the profile of the cam surface 13. The part of the cam surface 21 engaged by the roller follower 23 during an oscillation of the rocker 13 associated is indicated by the distance 'a' shown in figure 1. The roller follower initially moves along a part of distance 'a' in which no lift is imparted to the valve 10. This is achieved by the roller follower moving along the constant radius portion 'y' of the cam surface 21. Whilst the roller follower 23 moves along the part 'y' the pivoting of the rocker 15 is not converted into pivoting of the rocker 16 and the valve 10 is kept closed. On further pivoting of the rocker 15 the roller follower 23 engages the part 'z' of the cam surface 21 and the pivoting of the rocker 13 does cause pivoting of the rocker 16 and hence lift of the valve 10.

The control shaft 26 is rotated to move the roller follower 23 relative to the cam surface 21. By controlling how much of the distance 'a' (the distance on the control surface 21 along which the roller follower travels in each full oscillation of crankshaft 11) lies in the part 'y' of the cam surface 21 and how much lies in the part 'z' of the cam surface 21 the duration of valve opening can be varied. Simultaneously valve lift is varied since the valve lift will be greater the further the roller follower moves along the part 'z' of the surface 21. At one extreme the roller follower 23 can be moved to a position in which the roller follower 23 only moves along the portion 'y' of the cam surface 21 during a complete oscillation of the rocker 13 and the valve 10 is deactivated. At the other extreme the roller follower 23 can be moved to a position in which the roller follower starts at the meeting point of the parts 'y' and 'z' of the cam surface 21 and travels along part 'z' throughout rotation of rocker 13; this will give the inlet valve 10 a maximum opening period and also maximum lift.

Figure 2 shows a second embodiment of the valve operating mechanism . The second embodiment shares many components in common with the first embodiment and these are given identical reference numerals and their function will not be described again. Instead only the differences will be described.

In the figure 2 embodiment the roller follower 23 is rotatably mounted directly on the rocker 15, which does not have a reaction surface. The roller follower 23 will follow the cam surface 21 in the manner previously described with reference to figure 1. The

control shaft 26 is not rotated to change the position of the roller follower 23 as in the figure 1 embodiment, but instead is rotated to vary in position the limits between which the rocker 13 pivots. In the figure it can be seen that a link 112 is pivotally connected at one end to a throw of the crankshaft 11 and is pivotally connected at the other end to two control links 114 and 115. Control link 114 is pivotally connected at one end to the control link 112 and the other end is pivotally connected to the rocker 13. Control link 115 is pivotally connected at one end to the control link 112 and at the other end to a control arm 113. The control arm 113 is fixed to the control shaft 26 to rotate therewith. Rotation of the control shaft 26 can vary the geometry of the links 112,114,115 in order to alter the limits of pivoting of the rocker 13 and thereby the part of the cam surface 21 over which the roller follower 23 travels. Hence, valve lift and valve opening duration are varied.

The figure 2 embodiment could be advantageously used in a 'V' configuration engine since the control shaft 26 and the control links 112,114,115 could be located between the banks of cylinders.

The valve operating mechanism described above enables sufficient control over both valve lift and duration that when applied to operate the inlet valves of an engine the valves can be used to throttle the engine and there is no need for a separate e.g. butterfly throttle.

The motion of the roller follower 27 is rotation during valve operation and therefore does not generate

wherein:

the second rocker has a reaction surface which faces the cam surface of the first rocker;

the cam follower means comprises a follower member arranged between the cam surface and the reaction surface in simultaneous abutment with both surfaces;

the follower member moves along the cam surface of the first rocker as the first rocker rotates and follows a profile of the part of the cam surface engaged by the follower member;

the follower member engages the reaction surface of the second rocker in order to relay camming action of the cam surface to the second rocker and thereby cause the second rocker to pivot about the second rocker axis; and

the control mechanism moves the cam follower relative to the cam surface of the first rocker to vary which part of the cam surface is engaged by the cam follower during pivoting of the first rocker and thereby to vary the pivotal motion imparted to the second rocker and hence the motion of the poppet valve.

4. A valve operating mechanism as claimed in claim 3 wherein the control mechanism comprises:

a first control arm on which the follower member is mounted ; and

a second control arm to which the first control arm is pivotally connected such that the first control arm is freely rotatable about the pivotal connection; and

a control shaft on which the second control arm is mounted to rotate therewith; wherein

the control shaft is rotatable to act via the

first and second control arms to move the follower member so as to vary the part of the cam surface engaged by the follower member during pivoting of the first rocker.

5. A valve operating mechanism as claimed in claim 2 wherein:

the cam follower means comprises a follower member mounted on the second rocker;

the follower member moves along the cam surface of the first rocker as the first rocker pivots and follows a profile of the part of the cam surface engaged by the follower member whereby the camming action of the cam surface causes the second rocker to pivot about the second rocker axis; and

the control mechanism is connected to the first rocker via the drive mechanism and the control mechanism controls limits of the pivoting of the first rocker about the first rocker shaft in order to control which part of the cam surface is engaged by the cam follower during pivoting of the first rocker and thereby controls the pivotal motion imparted to the second rocker and hence the motion of the poppet valve.

6. A valve operating mechanism as claimed in claim 5 wherein:

the drive mechanism comprises:

a first connecting link pivotally connected at a first end to the rotating shaft and a second connecting link pivotally connected at a first end to a second end of the first connecting link and pivotally connected at a second end to the first rocker; and

the control mechanism comprises:

a control arm rotatable about a control shaft;

rotating means for rotating the control shaft and thereby the control arm; and

a control link pivotally connected at a first end to the control arm and pivotally connected at a second end to both the first end of the second connecting link and the second end of the first connecting link.

7. A valve operating mechanism as claimed in any one of claims 2 to 6 wherein:

the cam surface on the first rocker has a portion of constant radius with respect to the first rocker shaft and when the follower member engages the constant radius portion of the cam surface during pivoting of the first rocker then no lift is transmitted from the cam surface to the poppet valve; and

the control mechanism can constrain the follower member to move along the constant radius portion of the control surface for a part of an oscillation of the first rocker and the control mechanism can vary duration of poppet valve opening by increasing and decreasing in length a distance travelled by the follower member along the constant radius portion of the cam surface.

8. A valve operating mechanism as claimed in claim 7 wherein the control mechanism can deactivate the poppet valve by constraining the follower member to engage the constant radius portion of the cam surface of the first rocker throughout a complete oscillation of the first rocker.

9. A valve operating mechanism as claimed in claim 1 wherein:

the second rocker has a reaction surface which faces the cam surface of the first rocker;

the cam follower means comprises a follower member arranged between the cam surface and the reaction surface in simultaneous abutment with both surfaces;

the follower member moves along the cam surface of the first rocker as the first rocker rotates and follows a profile of the part of the cam surface engaged by the follower member; and

the follower member engages the reaction surface of the second rocker in order to relay camming action of the cam surface to the second rocker and thereby cause the second rocker to pivot about the second rocker axis.

10. A valve operating mechanism as claimed in claim 1 wherein:

the cam follower means comprises a follower member mounted on the second rocker; and

the follower member moves along the cam surface of the first rocker as the first rocker pivots and follows a profile of the part of the cam surface engaged by the follower member whereby the camming action of the cam surface causes the second rocker to pivot about the second rocker axis.

11. A valve operating mechanism as claimed in any one of claims 3 to 10 wherein the follower member is a roller follower and the first and second rockers when pivoting always pivot in opposite senses to one another.

12. An internal combustion engine having as inlet valves controlling gas flow into working cylinders a

plurality of poppet valves each operated by the valve operating mechanism claimed in any one of the preceding claims.

13. An internal combustion engine having as inlet valves controlling gas flow into working cylinders a plurality of poppet valves each operated by the valve operating mechanism claimed in any one of claims 2 to 8 wherein the lifts and opening durations of the poppet valves are varied to vary throttling of the engine.

14. An internal combustion engine having as exhaust valves controlling flow of combusted gases from working cylinders of the engine a plurality of poppet valves each operated by the valve operating mechanism claimed in any one of claims 1 to 11.

15. An internal combustion engine having as exhaust valves controlling flow of combusted gases from working cylinders of the engine a plurality of poppet valves each operated by the valve operating mechanism claimed in any one of claims 2 to 8 wherein the lifts and opening durations of the poppet valves are varied with variations in engine speed and/or load.

16. An internal combustion engine as claimed in claim 15 wherein in part load operating conditions of the engine the exhaust valves are each closed prior to the end of an exhaust stroke of the engine to trap combusted gases in the working cylinders, the trapped combusted gases being mixed with a charge of fuel and air in a subsequent intake stroke and the mixture of

trapped combusted gases, fuel and air igniting by a controlled auto-ignition process after compression.

17. A valve operating mechanism substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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Amendments to the claims have been filed as follows

17

CLAIMS

1. A valve operating mechanism for operating a poppet valve comprising:

a first rocker which is pivotally mounted on a first rocker shaft and which is driven to pivot in an oscillatory manner about the first rocker shaft;

a second rocker which is pivotally mounted on a second rocker shaft spaced apart from the first rocker shaft and which engages the poppet valve so that pivoting of the second rocker causes motion of the poppet valve; wherein

the first rocker has a cam surface; and

cam follower means engages the cam surface of the first rocker and relays a camming action of the cam surface to the second rocker to cause the second rocker to rotate about the second rocker shaft and thereby impart motion to the poppet valve;

characterised in that:

the first rocker is driven to pivot about the first rocker shaft by a drive mechanism which includes a rotating shaft and a connecting link pivotally attached to the rotating shaft at a point displaced from the axis of the shaft whereby the rotation of the shaft is used to drive the first rocker to pivot about the first rocker shaft both clockwise and anti-clockwise.

2. A valve operating mechanism as claimed in claim 1 wherein a control mechanism is provided to control which part of the cam surface of the first rocker is engaged by the cam follower means during pivoting of the first rocker.

3. A valve operating mechanism as claimed in claim 2

wherein:

the second rocker has a reaction surface which faces the cam surface of the first rocker;

the cam follower means comprises a follower member arranged between the cam surface and the reaction surface in simultaneous abutment with both surfaces;

the follower member moves along the cam surface of the first rocker as the first rocker rotates and follows a profile of the part of the cam surface engaged by the follower member;

the follower member engages the reaction surface of the second rocker in order to relay camming action of the cam surface to the second rocker and thereby cause the second rocker to pivot about the second rocker axis; and

the control mechanism moves the cam follower relative to the cam surface of the first rocker to vary which part of the cam surface is engaged by the cam follower during pivoting of the first rocker and thereby to vary the pivotal motion imparted to the second rocker and hence the motion of the poppet valve.

4. A valve operating mechanism as claimed in claim 3 wherein the control mechanism comprises:

a first control arm on which the follower member is mounted ; and

a second control arm to which the first control arm is pivotally connected such that the first control arm is freely rotatable about the pivotal connection; and

a control shaft on which the second control arm is mounted to rotate therewith; wherein

the control shaft is rotatable to act via the

first and second control arms to move the follower member so as to vary the part of the cam surface engaged by the follower member during pivoting of the first rocker.

5. A valve operating mechanism as claimed in claim 2 wherein:

the cam follower means comprises a follower member mounted on the second rocker;

the follower member moves along the cam surface of the first rocker as the first rocker pivots and follows a profile of the part of the cam surface engaged by the follower member whereby the camming action of the cam surface causes the second rocker to pivot about the second rocker axis; and

the control mechanism is connected to the first rocker via the drive mechanism and the control mechanism controls limits of the pivoting of the first rocker about the first rocker shaft in order to control which part of the cam surface is engaged by the cam follower during pivoting of the first rocker and thereby controls the pivotal motion imparted to the second rocker and hence the motion of the poppet valve.

6. A valve operating mechanism as claimed in claim 5 wherein:

the drive mechanism comprises:

a first connecting link pivotally connected at a first end to the rotating shaft and a second connecting link pivotally connected at a first end to a second end of the first connecting link and pivotally connected at a second end to the first rocker; and

the control mechanism comprises:

a control arm rotatable about a control shaft;

rotating means for rotating the control shaft and thereby the control arm; and

a control link pivotally connected at a first end to the control arm and pivotally connected at a second end to both the first end of the second connecting link and the second end of the first connecting link.

7. A valve operating mechanism as claimed in any one of claims 3 to 6 wherein:

the cam surface on the first rocker has a portion of constant radius with respect to the first rocker shaft and when the follower member engages the constant radius portion of the cam surface during pivoting of the first rocker then no lift is transmitted from the cam surface to the poppet valve; and

the control mechanism can constrain the follower member to move along the constant radius portion of the control surface for a part of an oscillation of the first rocker and the control mechanism can vary duration of poppet valve opening by increasing and decreasing in length a distance travelled by the follower member along the constant radius portion of the cam surface.

8. A valve operating mechanism as claimed in claim 7 wherein the control mechanism can deactivate the poppet valve by constraining the follower member to engage the constant radius portion of the cam surface of the first rocker throughout a complete oscillation of the first rocker.

9. A valve operating mechanism as claimed in claim 1 wherein:

the second rocker has a reaction surface which faces the cam surface of the first rocker;

the cam follower means comprises a follower member arranged between the cam surface and the reaction surface in simultaneous abutment with both surfaces;

the follower member moves along the cam surface of the first rocker as the first rocker rotates and follows a profile of the part of the cam surface engaged by the follower member; and

the follower member engages the reaction surface of the second rocker in order to relay camming action of the cam surface to the second rocker and thereby cause the second rocker to pivot about the second rocker axis.

10. A valve operating mechanism as claimed in claim 1 wherein:

the cam follower means comprises a follower member mounted on the second rocker; and

the follower member moves along the cam surface of the first rocker as the first rocker pivots and follows a profile of the part of the cam surface engaged by the follower member whereby the camming action of the cam surface causes the second rocker to pivot about the second rocker axis.

11. A valve operating mechanism as claimed in any one of claims 3 to 10 wherein the follower member is a roller follower and the first and second rockers when pivoting always pivot in opposite senses to one another.

12. An internal combustion engine having as inlet valves controlling gas flow into working cylinders a

plurality of poppet valves each operated by the valve operating mechanism claimed in any one of the preceding claims.

13. An internal combustion engine having as inlet valves controlling gas flow into working cylinders a plurality of poppet valves each operated by the valve operating mechanism claimed in any one of claims 2 to 8 wherein the lifts and opening durations of the poppet valves are varied to vary throttling of the engine.

14. An internal combustion engine having as exhaust valves controlling flow of combusted gases from working cylinders of the engine a plurality of poppet valves each operated by the valve operating mechanism claimed in any one of claims 1 to 11.

15. An internal combustion engine having as exhaust valves controlling flow of combusted gases from working cylinders of the engine a plurality of poppet valves each operated by the valve operating mechanism claimed in any one of claims 2 to 8 wherein the lifts and opening durations of the poppet valves are varied with variations in engine speed and/or load.

16. An internal combustion engine as claimed in claim 15 wherein in part load operating conditions of the engine the exhaust valves are each closed prior to the end of an exhaust stroke of the engine to trap combusted gases in the working cylinders, the trapped combusted gases being mixed with a charge of fuel and air in a subsequent intake stroke and the mixture of

trapped combusted gases, fuel and air igniting by a controlled auto-ignition process after compression.

17. A valve operating mechanism substantially as hereinbefore described with reference to and as shown in the accompanying drawings.